

Remote Delivery of Real-time Physiologic Data Over the World Wide Web

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Background. A large part of the rising cost of medical care, which has received relatively little attention, can be attributed to the use of more intensive health care resources. Nationwide, intensive care units (ICUs) are growing by 5 to 6% per year and account for 20% of total hospital expenditures.¹ Within these specialized healthcare environments, patients are connected to multiple bedside monitors each acquiring and displaying continuous streams of critical data that healthcare providers must supervise for extended periods of time. It is often the case that physicians and nurses are not available to continually monitor the patient's physiological data and that immediate access to real-time data from remote locations can provide healthcare providers the opportunity to interpret the monitor's data from home, the office, or even while traveling.

Objectives. An inexpensive monitoring interface that would allow healthcare providers immediate access to real-time physiological data from remote locations was sought. The WWW in conjunction with Sun Microsystems' new object-oriented programming language, Java, is used to realize such an interface by allowing the transfer of cross-platform applets to client computers with Internet or intranet access. To accomplish the user-interface of the online monitors (i.e., ECG, EEG, etc.), extensive classes of "medical widgets", realized with the new JDK 1.1 JavaBeans API, were derived from the foundation class MedicalMonitor via inheritance, an invaluable characteristic of object-oriented programming languages.

Methods. Physiological data is captured from bedside monitors via a 16-bit analog-to-digital converter (ADC) with National Instrument's LabVIEW V4.1. Included within LabVIEW's extensive library package is the ability to transfer data under the Transmission Control Protocol / Internet Protocol (TCP/IP) standard which enables communication over single networks (intranets) or multiple interconnected networks (Internet). Once the acquired data has been routed to the server's IP address, it is stored in a ring buffer which allows the transmission of data to the requesting computer (i.e., the client) from the Java-based server's port address. When a request is made of the server to access physiological data, the Java applet's bytecode is transferred to and interpreted by a platform-specific Web browser. After the user-interface is displayed within the browser, a socket connection is established between the server and the client with Java's java.net package allowing for the transmission of buffered streams of data to update the online monitor in real-time.

Conclusion. An inexpensive online monitor was developed with the object-oriented Java programming language to provide remote access to real-time physiological data over the Internet. Such a system allows medical professionals the opportunity to interpret critical information from remote locations and patients to submit real-time physiological data from remote locations. Thus, online monitoring can assist in a wide range of medical environments from the ICU to home-based medical care.

¹ Wagner DP, Wineland TD, Knaus WA. The hidden costs of treating severely ill patients: charges and resource consumption in an intensive care unit. *Health Care Financ Rev* 1983; 5:81-86.2